

Appl. No. 10/063,822
Amdt. Dated January 21, 2005
Reply to Office action of October 21, 2004

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A light emitting diode
5 comprising:

an insulating substrate;

a semiconductor stack positioned over the insulating
substrate, the semiconductor stack comprising a first
surface and a second surface, a distance between the
10 first surface and the insulating substrate is greater
than a distance between the second surface and the
insulating substrate;

a reverse-tunneling layer over the first surface, the
reverse-tunneling layer being a gallium nitride (GaN)
15 based semiconductor;

a first transparent ohmic contact electrode
positioned directly on the reverse-tunneling layer, the
first transparent ohmic contact electrode comprising an
oxide; and

20 a second transparent ohmic contact electrode
positioned over the second surface.

2. (Previously Presented) The light emitting diode of claim
1, wherein the insulating substrate comprises sapphire,
25 and the first transparent ohmic contact electrode and
the second transparent ohmic contact electrode comprise
the same non-metal material.

3. (Currently Amended) The light emitting diode of claim
30 1, wherein the first transparent ohmic contact electrode

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or the second transparent ohmic contact electrode
comprises at least one selected from a group comprising
indium tin oxide (ITO) [[,]] and cadmium tin oxide (CTO),
5 ~~and titanium tungsten nitride (TiWN).~~

4. (Cancelled)

5. (Original) A light emitting diode comprising:

- 10 an insulating substrate;
a buffer layer positioned on the insulating
substrate;
an n⁺-type contact layer positioned on the buffer
layer, the contact layer comprising a first surface and
15 a second surface;
an n-type cladding layer positioned on the first
surface of the n⁺-type contact layer;
a light-emitting layer positioned on the n-type
cladding layer;
20 a p-type cladding layer positioned on the
light-emitting layer;
a p-type contact layer positioned on the p-type
cladding layer;
an n⁺-type reverse-tunneling layer positioned on the
25 p-type contact layer;
a p-type transparent ohmic contact electrode
positioned on the n⁺-type reverse-tunneling layer; and
an n-type transparent ohmic contact electrode
positioned on the second surface of the n⁺-type contact
30 layer;

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wherein the p-type transparent ohmic contact electrode and the n-type transparent ohmic contact electrode comprise the same materials.

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6. (Original) The light emitting diode of claim 5 wherein the insulating substrate comprises sapphire.

7. (Currently Amended) The light emitting diode of claim
10 5 wherein the p-type transparent ohmic contact electrode and the n-type transparent ohmic contact electrode are made of at least one selected from a group comprising indium tin oxide[[,]] and cadmium tin oxide, ~~and~~
~~titanium tungsten nitride.~~

15

8. (Cancelled)

9. (Cancelled)

20 10. (Currently Amended) A light emitting diode comprising:
an insulating substrate;

a semiconductor light emitting stack positioned over the insulating substrate, the semiconductor light emitting stack comprising a first surface and a second
25 surface, a distance between the first surface and the insulating substrate is greater than a distance between the second surface and the insulating substrate;

a reverse-tunneling layer over the first surface, the reverse-tunneling layer being a gallium nitride (GaN)
30 based semiconductor;

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a first non-metal transparent ohmic contact electrode positioned over the ~~first surface~~ reverse-tunneling layer; and

5 a second non-metal transparent ohmic contact electrode positioned over the second surface,

wherein the first non-metal transparent ohmic contact electrode and the second non-metal transparent ohmic contact electrode comprise the same oxide
10 material.

11. (Currently Amended) The light emitting diode of claim 10, wherein the first non-metal transparent ohmic contact electrode and the second non-metal transparent
15 ohmic contact electrode comprise at least one selected from a group comprising indium tin oxide (ITO) ~~[[,]]~~ and cadmium tin oxide (CTO), ~~and titanium tungsten nitride (TiWN).~~

20 12. (Currently Amended) A light emitting diode comprising:
an insulating substrate;

a semiconductor stack positioned over the insulating substrate, the semiconductor stack comprising a first surface and a second surface, a distance between the
25 first surface and the insulating substrate is greater than a distance between the second surface and the insulating substrate;

a reverse-tunneling layer, which is a gallium nitride (GaN) based semiconductor that has a carrier
30 concentration of approximately $1.5 \times 10^{20} \text{ cm}^{-3}$, over the

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first surface;

a first transparent ohmic contact electrode directly
on the reverse-tunneling layer, the first transparent
5 ohmic contact electrode comprising an oxide; and

a second transparent ohmic contact electrode over the
second surface.

13. (Previously Presented) The light emitting diode of
10 Claim 12, wherein the reverse-tunneling layer has a
thickness of approximately 20 angstroms..

14. (Currently Amended) A light emitting diode comprising:
an insulating substrate;

15 a semiconductor stack positioned over the insulating
substrate, the semiconductor stack comprising a first
surface and a second surface, a distance between the
first surface and the insulating substrate is greater
than a distance between the second surface and the
20 insulating substrate;

a reverse-tunneling layer over the first surface, the
reverse-tunneling layer being a gallium nitride (GaN)
based semiconductor; and

a first transparent ohmic contact electrode directly
25 on the reverse-tunneling layer, the first transparent
ohmic contact electrode comprising an oxide.

15. (New) A light emitting diode comprising:
an insulating substrate;

30 a buffer layer positioned on the insulating

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substrate;

an n-type contact layer positioned on the buffer layer,
the contact layer comprising a first surface and a second
5 surface;

an n-type cladding layer positioned on the first
surface of the n-type contact layer;

a light-emitting layer positioned on the n-type
cladding layer;

10 a p-type cladding layer positioned on the
light-emitting layer;

a p-type contact layer positioned on the p-type
cladding layer;

an n⁺-type reverse-tunneling layer positioned on the
15 p-type contact layer;

a p-type transparent ohmic contact electrode
positioned on the n⁺-type reverse-tunneling layer; and

an n-type transparent ohmic contact electrode
positioned on the second surface of the n⁺-type contact
20 layer;

wherein the p-type transparent ohmic contact
electrode and the n-type transparent ohmic contact
electrode comprise the same materials.

25 16. (New) The light emitting diode of claim 15 wherein the
insulating substrate comprises sapphire.

17. (New) The light emitting diode of claim 15 wherein the
p-type transparent ohmic contact electrode and the
30 n-type transparent ohmic contact electrode are made of

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at least one selected from a group comprising indium tin
oxide and cadmium tin oxide.